IJCSC International Journal of Computer Science and Communication Vol. 2, No. 2, July-December 2011, pp. 565-575

PERFORMANCE EVALUATION AND SIMULATION BASED MODELING OF ENERGY AWARE VARIABLE RANGE DSR (VRDSR) PROTOCOL

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ABSTRACT

Energy management is an important issue in Mobile Ad Hoc Networks (MANETs). Normally MANETs use common transmission range for data transfer. Transmitting with high power improves network performance by reducing the number of forwarding nodes. However, it results in interference and decreases network lifetime. We have tried variable range transmission power control with Dynamic Source Routing (DSR) protocol. Transmission range is adjusted dynamically depending on node distance. Network performance is tested against variation in pause time, speed and node density with the modified protocol, VRDSR and DSR. Results show effective node energy utilization. In this paper, we have tried to model the network behavior based on simulation output. The work also describes analytical modeling of the protocol performance to predict correct network behavior for future instances quickly without carrying out simulations. This technique helps in efficiently estimating the performance of network with modified protocol, under study.

Keywords: MANET, VRDSR, Modeling.

1. INTRODUCTION

MANET is a dynamic, multi-hop and autonomous network composed of wireless mobile nodes usually having a routable networking environment. MANETs represent complex distributed systems that comprise wireless mobile nodes that can freely and dynamically self-organize into arbitrary and temporary, ad-hoc network topologies. This allows people and devices to seamlessly internetwork in areas with no pre-existing communication infrastructure, like disaster recovery environments [1]. The main goal of mobile ad hoc networking is to extend mobility into the realm of autonomous, mobile, wireless domains, where a set of nodes, which may be combined routers and hosts, form the network routing infrastructure in an ad hoc fashion [2]. The application fields of these networks can be in military, personal area network, business indoor application, civil outdoor application, emergency application, emergency application and home intelligence devices [3]. All application areas have some features and requirements for which use of protocols is common.

Limited resource availability such as battery power and security are the major issues to be handled with mobile ad hoc networks. Especially, energy efficient routing is most important because all the nodes are battery powered. Failure of one node may affect the entire network. If a node runs out of energy the probability of network partitioning will be increased. Since every mobile node has limited power supply, energy depletion is one of the main threats to the lifetime of the ad hoc network. For this reason routing is an important part of MANET. Transmission power control approach is used to adjust the node to node communication power and load balancing approach is used to avoid over utilized nodes. Transmission power control is done by calculating new transmission power between every pair of nodes on that route which will be the minimum power required for successful communication [4]. More energy is required if there are obstacles in the transmission path. Hence, energy is conserved by using multihop routing, that is, nodes between the source and destination are used as relays. When node selects shorter route the energy consumption is less and battery life for the node is better. Efficient battery management, transmission power management, and system power management are the three major ways of increasing the life of a node.

Mobility is the key characteristic of a MANET and presence of static routes in such a network is very rare. It is difficult to find a route which is completely static. So, the route which is less dynamic as compared to the other routes should be chosen as the best route.

We present remainder of the paper as follows. In Section 2 we discuss issues of routing protocols and energy efficient routing protocol techniques in MANET. Original DSR protocol features that are proposed to be modified are also discussed. Section 3 describes our scheme VRDSR for making DSR energy efficient by modifying existing protocol. Section 4 includes simulation environment scenario used in NS-2 simulator. Section 5 shows performance comparison of DSR and variable range DSR protocol based on simulation results. The Analytical modeling technique and matching of simulated and model based results are illustrated in Section 6. Section 7 concludes the work focusing on two parts, improvement in network behavior by using modified protocol, and use of analytical modeling for better understanding of network.

2. LITERATURE SURVEY

Routing in ad hoc network is a technique that controls how nodes decide which way to route packets between computing devices in a mobile ad hoc network. The traditional routing algorithms lack power-aware routing. MANETs are dynamic, so network links keep on changing. Thus some nodes may need to be notified to recalculate their routes in this response [5]. The manner in which routing tables are constructed, maintained and updated differ from one routing method to another [6]. Dynamic routing protocols are classified depending on what the routers tell each other and how they use the information to form their routing tables. Conventional routing algorithms in MANETs are distance vector, link state and source routing.

The DSR is simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks with very high rates of mobility. It is reactive and route discovery cycle used for route finding is "on demand". This protocol is truly based on source routing whereby all the routing information is maintained (continually updated) at mobile nodes instead of relying on the routing table at each intermediate device. There are two main mechanisms in DSR called Route Discovery and Route Maintenance. Route Discovery determines the optimum path for a transmission between a given source and destination. In DSR when a mobile node has a packet to send to some destination it first consults its route cache to determine whether it already has a route to the destination. If it has an unexpired route to the destination, it will use this route to send the packet [7]. If node does not know a route to destination; it should begin the route discovery process.

Route Maintenance is initiated whereby the Route Error packets are generated at a node. The erroneous hop will be removed from the node's route cache, all routes containing the hop is truncated at that point [8]. Again, the Route Discovery Phase is initiated to determine the most viable route. Route Maintenance ensures that the transmission path remains optimum and loop-free as network conditions change, even if this requires changing the route during a transmission. All states maintained by DSR are "soft state"[9], in that the loss of any state will not interfere with the correct operation of the protocol. All states are discovered as required and can easily and quickly be rediscovered if needed after a failure without significant impact on the protocol [10]. Various techniques for making routing protocol energy efficient are considered. Saoucene Mahfoudh, Pascale Minet [11] have distinguished three families of energy efficient routing protocols. Few proposals especially focused on the design of routing protocols providing efficient power utilization are dealt in depth by C.K.Toh [12].

3. PROPOSED WORK

DSR being reactive protocol consumes less energy. To make network operation energy aware we have used DSR for our experimentation. Energy efficient design of the protocol can be generated using the variable transmission range. The modifications in the MAC layer are done, as it is major part of controlling the different parameters of network behavior. In our work, we study the impact of variable-range transmission power control on the power savings of wireless multihop networks. The nodes individually control the transmission ranges as per the distance between the source and destination node, so that they can transmit the packet with optimum energy. Correct choice of transmission power is crucial. Power control affects the physical layer performance. Choosing a high transmission range reduces the number the forwarding nodes needed to reach the destination, but creates large interference. Reducing the transmission range demands more number of forwarding nodes but energy utilization is less. The comparison of different parameters for the network is done for both the protocols.

Range is an important requirement for any RF application. Long range is achieved through greater receiver sensitivity. The best receiver sensitivity is desirable as it lowers the power requirement allowing detection of weaker signals and can increase the transmission range. IEEE 802.11 MAC protocol with constant transmission bandwidth of 2 Mbps, have received power range as – 81.0 to – 110 dBm [13]. We have considered our threshold value slightly more (–82.52 dBm) than mentioned in specification to ensure effective data transmission. As data rate reduces there is increase in transmission as well as sensing range (sensing range should be larger than transmission range).

3.1 Transmitter Power Details

We have used Friss transmission equation to calculate transmit power [14]. In original equation we have taken transmitter antenna gain (Gt) and receiver antenna gain (Gr) as unity and path loss component (n) as 2 for Friss space communication. The equation taken into consideration is,

$$\frac{Pr}{Pt} = \left(\frac{\lambda}{4\pi R}\right)^2 \quad (1)$$

In the equation, the terms *Pr* and *Pt* denote received and transmitted powers; *R* is the distance between the nodes and λ is the wavelength taken as 0.122 m (at 2.422 GHz operating frequency) for calculations. We have maintained *Pr* constant at –82.52 dBm. Based on measured distance between the nodes, *Pt* required for transmission can be calculated. Few examples of distances and accordingly the *Pt* values are shown in Table 1. From equation (1) we can see that as distance increase, transmitter power requirement also increases.

Table 1
Expected Pt Values for Different Distance Values

Distance (m)	*Pt (dBm)*
100	-8.5
250	-0.3
400	3.7657
550	6.53
700	8.62
850	10.315
1000	11.46

3.2 Implemented Algorithm

Our algorithm for VRDSR is as follows:

1. Send the route request message for Route Discovery to find all the possible destination paths, when node needs to send the data.
2. Calculate the signal to interference which is ratio of power of transmitted node to received node.
3. Calculate the distance between the nodes (on the path) by using Euclidian method.
4. Set the transmission range of each node, using relationship given by Equation (1), keeping received power threshold constant.
5. Select the shortest route to the destination and send the packets.
6. Maintain the route between the source and the destination in order to ensure connection establishment.
7. If the route is broken check the available path and if not present repeat from Step 1.

4. SIMULATION SCENARIO

We carried out simulation for common range and VRDSR. NS-2.33 is used to compare the two ad hoc routing protocols. The underlying MAC layer protocol is defined by IEEE 802.11 standard [15]. Our algorithm is simulated for network parameters defined in section 4.1.

4.1 Parameter Definitions

The parameters selected for protocol comparison are related to energy consumption of a node and the overall network. Average residual energy of a node will depend upon role of a node as ((transmitter/ receiver), router and frequency of usage). Our aim is to use the node effectively by saving energy consumed per operation. Control overheads namely Normalized Routing Load and Normalized MAC load are also responsible for energy consumption. For energy aware operation we want more number of alive nodes to improve network lifetime.

The parameter definitions are as follows:

i) *Minimum node energy:* Minimum node energy is the residual energy of a node among all intermediate nodes that had the smallest residual energy [16]. This can also be referred as Average Residual Energy. It is important as defines the remaining energy of the network and in turn reflects the network utilization time.

ii) *Normalized Routing Load:* These are the number of routing packets transmitted per data packet delivered at the destination. Each hop -wise transmission of a routing packet is counted as one transmission [17].

iii) *Normalized MAC Load:* The number of routing, Address resolution protocol (ARP), and control (e.g., RTS, CTS, ACK) packets transmitted by the MAC layer for each delivered data packet [18].

iv) *Number of Alive Nodes:* Number of alive nodes was the number of nodes whose energy is not exhausted after simulating over certain period of time. After simulating over a certain period of time, the more the number of alive nodes is, the better the performance the network is [16].

v) *Network Lifetime:* The time of first node failure due to the exhaustion of battery power charge during the simulation with a particular routing protocol.[19]

We observed the effect of variation of pause time, speed and number of nodes on both the protocols. As we are considering node mobility issue, both, speed and pause time play major role. Depending upon their values, the nodes move making the scenario dynamic, leading to few path breaks. Number of nodes i.e. node density for fixed area shows the network state (sparse or dense) and how it affects protocol behavior.

Simulations are carried out for three input parameter variations. They are listed at the top of three columns in Table 2. The variable parameter entry in a column is varied only for that particular parameter. Other parameter values are same for the three cases.

Table 2
Parameter Selection used for the Simulation

Parameters	*Number of nodes*	*Speed (meter/sec.)*	*Pause time (seconds)*
Network Area	1000*1000	1000*1000	1000*1000
Pause Time (seconds)	10	10	0,20,40,60,80,100
Mobility (meter/sec.)	20,40,60	0,5,10,15,20,25	20
No. of Nodes	20,30,40,50,60	25	50
No. of connection	10,15,20,25,30	15	25
Data Packet Size	512 bytes	512 bytes	512 bytes
Initial Energy	100.0J	100.0J	100.0J

We have considered field size as 1000*1000 sq. meters by referring most of simulation trials to earlier work. Pause time can be from 0 seconds to half of simulation time, lower the value more mobile is the node. Speed is varied from minimum (0 m/s) to high speed case (60 m/s). From our previous trial experience we have selected total nodes present in the network [20]. Number of connections among the nodes is usually half the node count and accordingly the value is selected. A medium data packet rate is selected for the connections. Total simulation interval considered for experimentation is of 200 seconds. Initial node energy and communication range are interrelated. If node energy is more, then communication range can be large and vice versa.

4.2 Considerations for Mobility Model used for Simulation

The performance of ad hoc routing protocols greatly depends on the mobility model used. Random Waypoint is considered to be an entirely random scheme and intuitively can be the most challenging environment for ad hoc routing protocols [21]. We analyze our protocol using random way point mobility model which provides worst case test conditions with various dynamic situations.

5. RESULTS

Comparative results for both protocols tested for node, speed and pause time variation for different parameters those are defined in Section 4.1. We are using following abbreviations for network parameters- Average Residual Energy (ARE), Normalized routing load (NRL), Normalized MAC load (NML), Number of alive nodes (NA) and Network Lifetime (NLT).

5.1 Effect of Nodes Variation on Common and Variable Range DSR Protocols

i) ARE for Two Protocols at Two Speeds: 20 m/s and 60 m/s

It is seen from Fig. 1, that as number of nodes increase, average residual energy reduces. These trials are carried out at different speeds and two cases are illustrated for 20 m/s and 60 m/s speeds. For higher speed condition the average residual energy is less as compared to lower speed. At higher speeds as node mobility is more, path breaks are more, this requires new route discovery, increasing routing overhead. This consumes more power per node, hence residual energy reduces. Variable range protocol shows superior performance for node variation and various speed conditions.

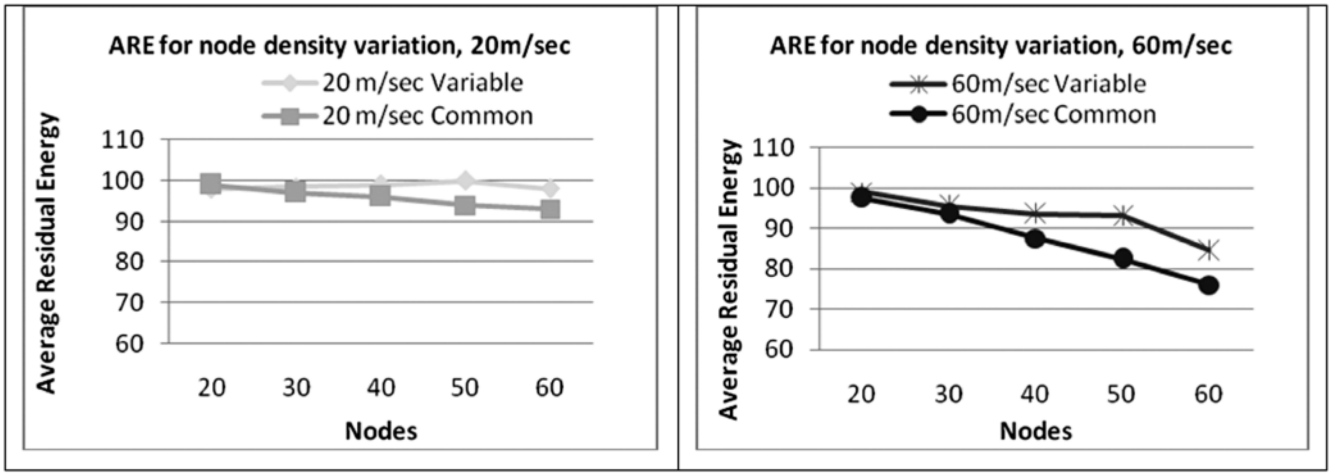

Figure 1: ARE Comparison of Both Protocols for Node Density Variation

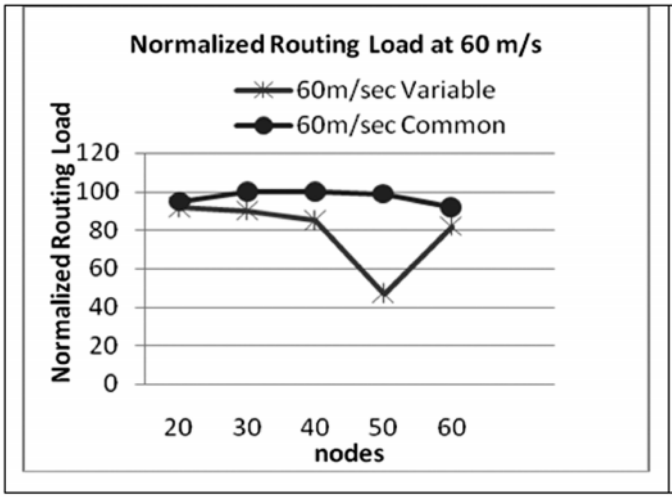

Figure 2: NRL for Node Variation

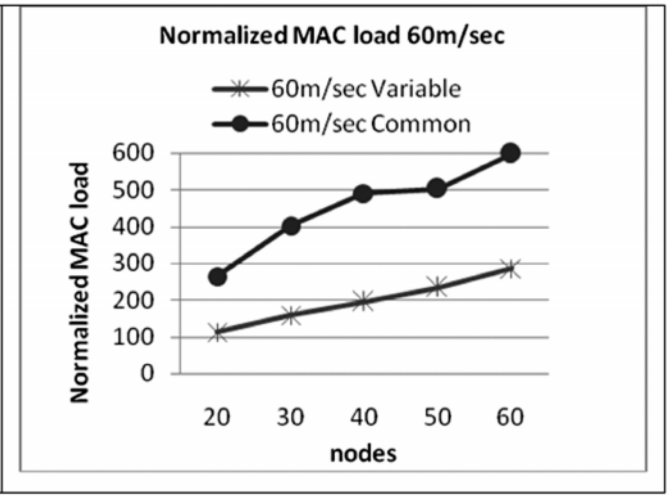

Figure 3: NML for Node Variation

ii) Normalized Routing Load

The trials are carried out at three speed conditions mentioned in Table 2. The result for 60 m/s speed is illustrated in Fig. 2. For variable range protocol, the overheads i.e NRL is less as the protocol is energy aware.

iii) Normalized MAC Load

For speeds 20 m/s and 40 m/s the NML for variable range is less as compared to common range. The result for 60 m/s speed is illustrated in Fig. 3. Since the power is adjusted based on distance in variable range protocol, the overheads namely routing and MAC loads are less. The NML value for variable range is smaller as compared to common range NML value.

iv) Number of Alive Nodes

In Fig. 4, NA count shows marginal improvement for variable range over common range for node variation. As the transmitted power is adjusted according to distance in our modified protocol, it will effectively use available node energy increasing the Number of nodes alive.

v) Network life time

NLT for node variation at speed 20 m/s is seen in Fig. 5. There is no significant difference in NLT parameter for variable as well as common range. It is observed that as node count increases, network lifetime decreases.

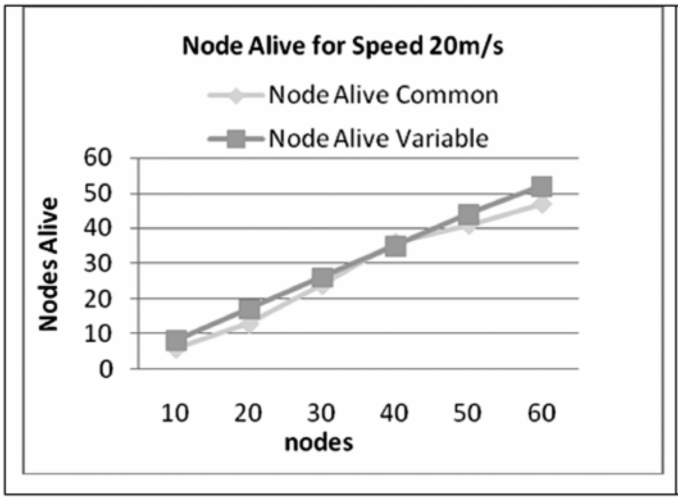

Figure 4: NA for Node Variation

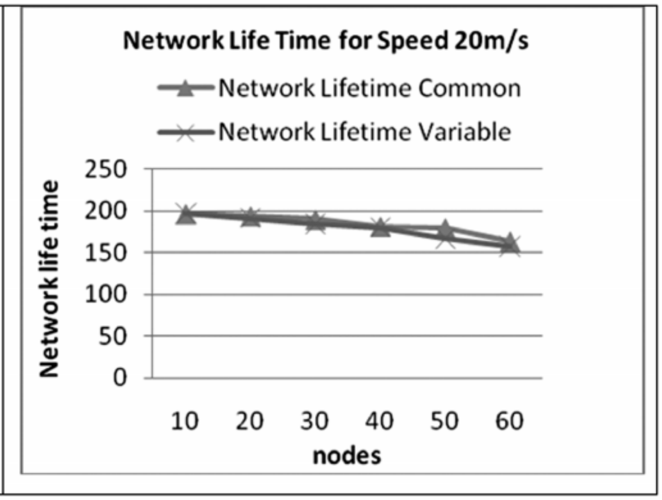

Figure 5: NLT for Node Variation

5.2 Effect of Speed Variation on Common and Variable Range DSR Protocols

We have modified protocol for energy efficiency, hence energy related parameters NA and NML are considered further for speed variation trials.

i) Network Life Time (for 50 Nodes and Pause Time 10 s)

From Fig. 6 it is seen that variable range protocol has more NLT as compared to common range DSR.

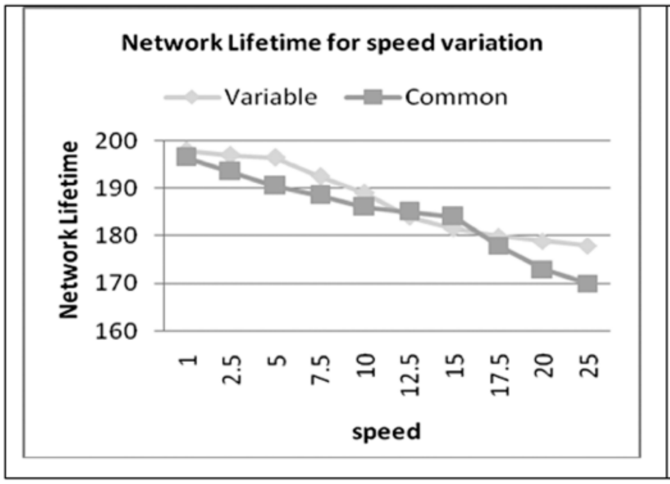

Figure 6: NLT for Speed Variation

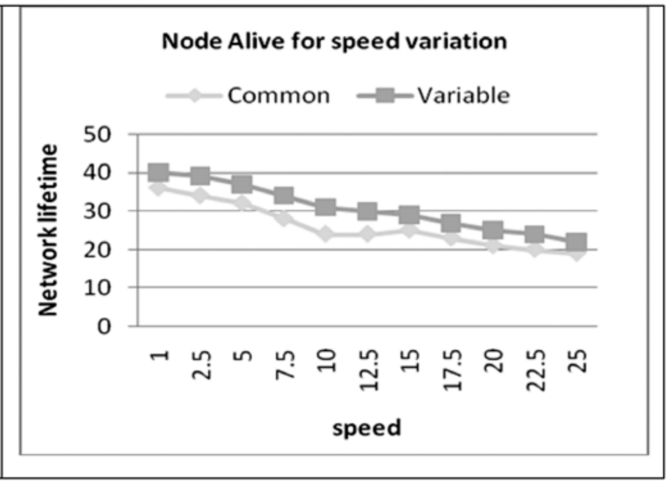

Figure 7: NA for Speed Variation

ii) Number of Nodes Alive (for 50 Nodes and Pause Time 10 s)

NA for variable range shows improvement over common range, as given in Fig. 7.

Improvement in NA and NLT for speed variation is due to less control overheads (NRL,NML) and in turn more ARE per node for variable range protocol.

5.3 Effect of Pause Time Variation on Common and Variable Range DSR Protocols

i) Network Life Time (for 50 nodes and speed 20 m/s)

When pause time is increased beyond 50 seconds, there is 5% - 6% improvement in NLT for variable range as seen in Fig. 8.

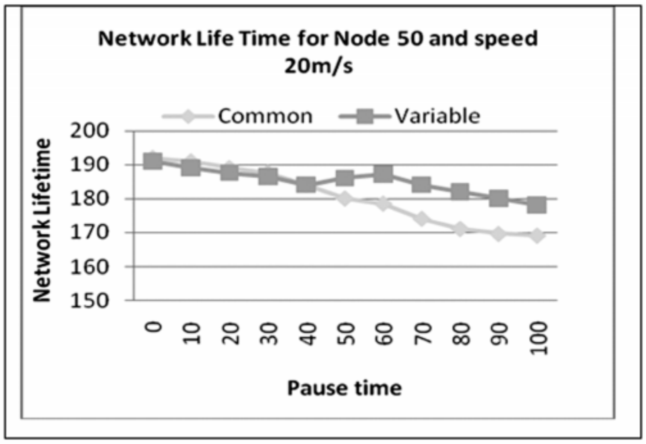

Figure 8: NLT for Pause Time Variation

6. ANALYTICAL MODELING FOR PROTOCOL

Analyzing the results of simulation models is certainly an area of utmost importance. The highly auto correlated nature of responses has challenged simulation analysis to propose ever more innovative approaches. Fishman [22] has suggested fitting an autoregressive model as an intermediate step for estimating reliable variability measures of the response. We have investigated the applicability of ARMA models for simulation of modified protocol under various scenarios. Based on simulation results, we further tried to express the network behavior with the analytical model which helps to estimate future values. These analytical models will provide feedback with regard to the impact of implementation decisions on overall deployment performance. In real-time decision making approach, this modeling will help in selecting a routing protocol, in reasonable amount of time and resources. The main purpose of finding simple but realistic analytical models helps in implementing modifications. Also, if the end user specifies limited parameters it can be very easy to suggest remaining parameters energy efficient network configuration without actual simulation.

Regression models are the mainstay of predictive analytics. The focus lies on establishing a mathematical equation as a model to represent the relation between the different variables in consideration. Classical regression is often insufficient for explaining all of the interesting dynamics of data sequence. As the regression did not capture additional structure in the data, the introduction of correlation as a phenomenon that may be generated through lagged linear relations leads to proposing the autoregressive (AR) and autoregressive moving average (ARMA) models. Model should be selected such that it contains few parameters while still maintaining the quality and the predictive ability of the model indicating tradeoff between simplicity and accuracy of a model.

The choice of model always involves the conflict between bias or mean and variance. Different tools used for Time Series Analysis are auto-covariance function, cross covariance function. The auto covariance measures the linear dependence between two points on the same series observed at different times. Normalized version of co variance is correlation. Correlation is primarily used to determine if a linear model can explain the relationship and it is a mathematical measure.

Based on above information possible models that can fit for given data are:

1. *AR models:* models that express the predictable part of present condition of process as part of past condition. AR models are suited to processes with exponentially decaying Auto correlation function (ACF).
2. *Moving average (MA) model:* models that express the predictable part based on shock waves experienced as part of past condition, not very popular for estimation, as based on non-linear algorithms. MA models are suitable to model process with sharp decaying Partial Auto Correlation Function (PACF). The term white noise 'Wt' appearing in MA equation is assumed to be Gaussian white noise and is combined linearly to form the observed data.
3. *ARMA models:* based on present condition (MA) that involves past history (AR) and inputs that drive the system. It is combination of AR and MA hence, can handle a large class of stationary processes exhibit mixed effects.

6.1 Estimation

Estimation is one of the most important aims of analyzing a data sequence. Estimation theory deals with estimating the values of parameters based on measured data that has a random component. An estimator attempts to approximate the unknown parameters using the measurements.

We are using R software for analytical modeling as it is powerful open source software package exclusively meant for statistical data analysis.

6.2 Modeling Technique Used

In our approach, we start from measurements of the behavior of the systems and we also consider the influence of applied input to determine a mathematical relationship amongst the input and output parameters or variables. Set of equations can easily establish the relationship between variables and we can forecast the system behavior at any desirable instant as well as at some future value.

The training data is used to estimate the model parameters. An accurate model will closely match the verification data even though this data was not used to set the model's parameters. For the modeling, results have been processed for getting AR, MA or ARMA models. By comparing the results of the ACF and PACF of the series with standard table, we can select the type and order of the model. Proper model is established to fit the data series and the results are validated against observed data. Final relation can be obtained by substituting the coefficients in the model equation.

6.3 Results of Analytical Modeling

For analysis of the two protocols (VRDSR and DSR) for estimating future values is based on technique explained in Section 6.2. With obtained simulation results in Section 5, we tried to fit the model. The results are represented in the form of equations, showing different models representing the protocol behavior.

6.3.1 Effect of Nodes Variation on Two Protocols Common Range DSR and VRDSR

i) *Average residual energy at two speed conditions as 20 m/s & 60m/s*

a. *Speed 20 m/s:*

Variable range:

$$\text{ARE}_{(n)} = 98.9087 + W_{(n)} + 0.5560{*}W_{(n-1)} \tag{2}$$

Calculated values for parameter for corresponding number of nodes are obtained from these equations representing the analytical model. The equation contains white noise denoted by W, generated by *R* software and we can predict the future values as sample prediction case ($W_{(n)}$ is present value and $W_{(n-1)}$ is the past value). The present value of parameter is denoted by $ARE_{(n)}$ and the past value is given by $ARE_{(n-1)}$.

MA model fits for variable range and the estimated value using the Equation (2) is 99.48 in place of 98 for 60 nodes condition. In the equation ARE is abbreviated for average residual energy.

Common range:

$$ARE_{(n)} = 49.4273 + 0.4878{*}ARE_{(n-1)} + W_{(n)} + 0.3017{*}W_{(n-1)} \tag{3}$$

ARMA model fits for common range, as past value and white noise; both terms are involved in the equation. The estimated value using the equation is 94.637 in place of 93 for 60 nodes.

b. *Speed 60 m/s:*

Variable range:

$$ARE_{(n)} = 44.3461+0.5376{*}ARE_{(n-1)} + W_{(n)} + 1.0000{*}W_{(n-1)} \tag{4}$$

ARMA model fits and the estimated value using the equation is 93.43 instead of 84.5 for 60 nodes condition.

Common range:

$$ARE_{(n)} =75.16 + ARE_{(n-1)} + W_{(n)} + 0.1253{*}W_{(n-1)} \tag{5}$$

ARMA model suits and the estimated value using the equation is 81.95 in place of 76 for 60 nodes.

ii) *Normalized routing load (at speed 60 m/s):*

Variable range:

$$NRL_{(n)} = 88.7019 - 0.1411^{*}NRL_{(n-1)} + W_{(n)} + 0.3142^{*}W_{(n-1)} \quad (6)$$

ARMA model is found to fit the variable range protocol. Estimated value is 72.15 in place of 82 for the case of 60 nodes. The variation between simulation and calculated value is more. This is due to abrupt fall of *NRL* at 50 nodes and again rises in *NRL* value at 60 nodes as seen from simulation results.

Common:

$$NRL_{(n)} = 116.9960 - 0.1834^{*}NRL_{(n\text{-}1)} + W_{(n)} - 0.9999^{*}W_{(n-1)} \quad (7)$$

ARMA model is suitable for common range protocol. Estimated value is 98.21 in place of 92 for 60 nodes.

iii) *Normalized MAC load (speed 60 m/s):*

Variable:

$$NML_{(n)} = 57.5908 + 0.6685^{*}NML_{(n-1)} + W_{(n)} + 0.7219^{*}W_{(n-1)} \quad (8)$$

ARMA model is found to fit the variable range protocol, estimated value is 240.93 in place of 286.3 for 60 nodes and at speed of 60 m/s.

Common:

$$NML_{(n)} = 0.704 + 0.9996^{*}NML_{(n-1)} + W_{(n)} + 0.5159^{*}W_{(n-1)} \quad (9)$$

ARMA model is found to fit the common range protocol, estimated value is 500.76 in place of 598.5 for 60 nodes and at speed of 60 m/s.

iv) *Number of alive Nodes (speed 20 m/s):*

Variable:

$$NA_{(n)} = 4.0976 + 0.8424^{*}NA_{(n-1)} + W_{(n)} + 1.0000^{*}W_{(n-1)} \quad (10)$$

ARMA model is suitable, estimated value is 45.56 in place of 52 for 60 nodes.

Common:

$$NA_{(n)} = 4.4189 + 0.8053^{*}NA_{(n-1)} + W_{(n)} + 1.0000^{*}W_{(n-1)} \quad (11)$$

ARMA model is suitable, estimated value is 38.68 in place of 47 for 60 nodes.

v) *Network life time (for speed 20 m/s):*

Variable:

$$NLT_{(n)} = 63.3916 + 0.6504^{*}NLT_{(n-1)} + W_{(n)} + 0.7445^{*}W_{(n-1)} \quad (12)$$

ARMA model is found to fit the variable range protocol, estimated value is 163.76 in place of 157.1 for 60 nodes and at speed of 20 m/s.

Common:

$$NLT_{(n)} = 44.0522 + 0.7655^{*}NLT_{(n-1)} \quad (13)$$

For common range *DSR* protocol, modeling results show that *AR* model can estimate the values. The present value of *NLT* denoted by $NLT_{(n)}$ can be obtained by substituting past values of *NLT* represented as $NLT_{(n-1)}$. We can get set of values for different number of nodes conditions. The observed and estimated values are shown in Fig. 9. The calculated values are obtained using Equation (13). It is observed from graph that estimated values match closely with observed ones, justifying our model.

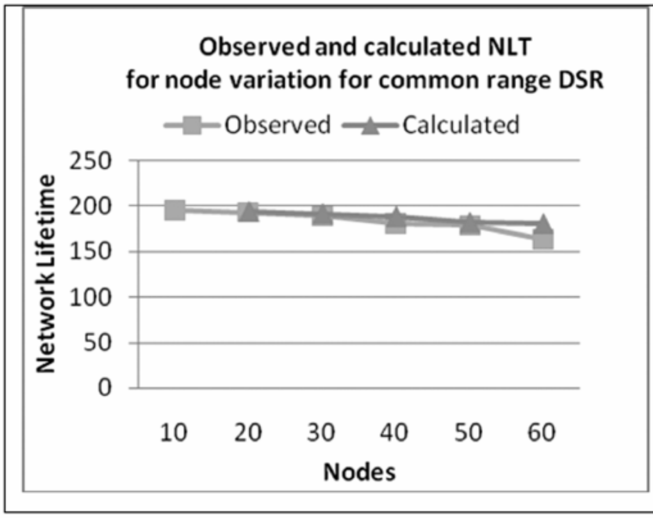

Figure 9: Observed, Calculated NLT

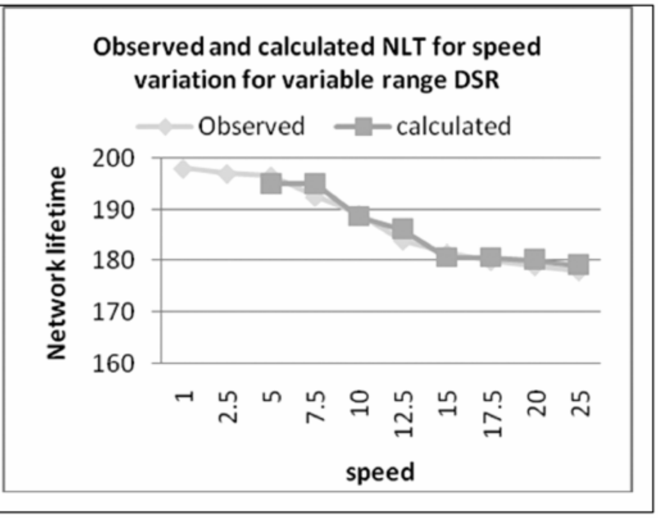

Figure 10: Observed, Calculated NLT

6.3.2 Effect of Speed Variation on Two Protocols Common Range DSR and VRDSR

i) *Network life time (for 50 nodes and pause time 10 s):*

The equations representing the common range and variable range protocol are given in Equation (14) and (15).

Variable:

$$NLT_{(sp)} = 30.13+1.69*NLT_{(sp-1)} - 0.849*NLT_{(sp-2)} \quad (14)$$

AR model is found to fit the variable range protocol. The present value of *NLT* at present speed is denoted by $NLT_{(sp)}$ and the past value is $NLT_{(sp-1)}$ and $NLT_{(sp-2)}$ is previous past value. The values are estimated by using past values in the equation and corresponding graph of observed (simulated) and calculated values is shown for 50 nodes and at variable speed condition. It is observed from graph in Fig. 10 that both the values match very closely

Common:

$$NLT_{(sp)} = 18.33 + 0.9*NLT_{(sp-1)} + W_{(sp)} + 1.0*W_{(sp-1)} \quad (15)$$

ARMA model is found to fit the common range protocol, estimated value is 174.37 in place of 173 for 50 nodes and at speed of 20 m/s.

ii) *Number of alive nodes (for 50 nodes and pause time 10 s):*

After modeling it is observed that for both the protocols *AR* model is suitable and estimated values and corresponding graphs are given in Fig. 11, 12 respectively.

Variable:

$$Node\ Alive_{(sp)} = 1.114 + 0.9651*Node\ Alive_{(sp-1)} \quad (16)$$

Common:

$$Node\ Alive_{(sp)} = 1.537 + 0.9445*Node\ Alive_{(sp-1)} \quad (17)$$

It is observed from graph, that both the values match very closely in both the cases of protocols, i.e. model fits correctly.

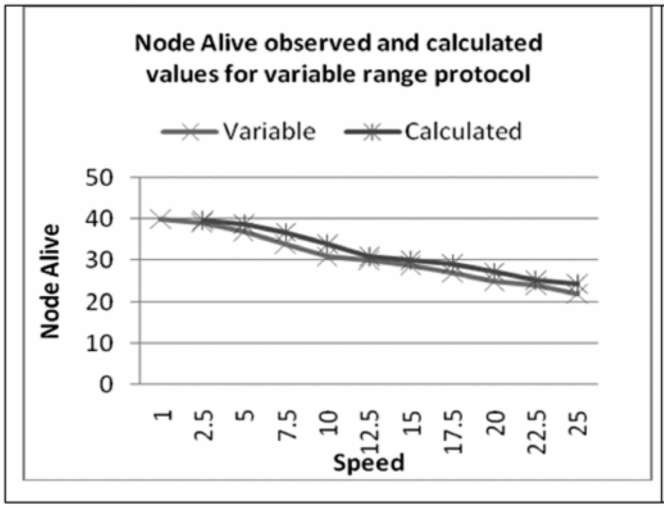

Figure 11: Observed, Calculated NA

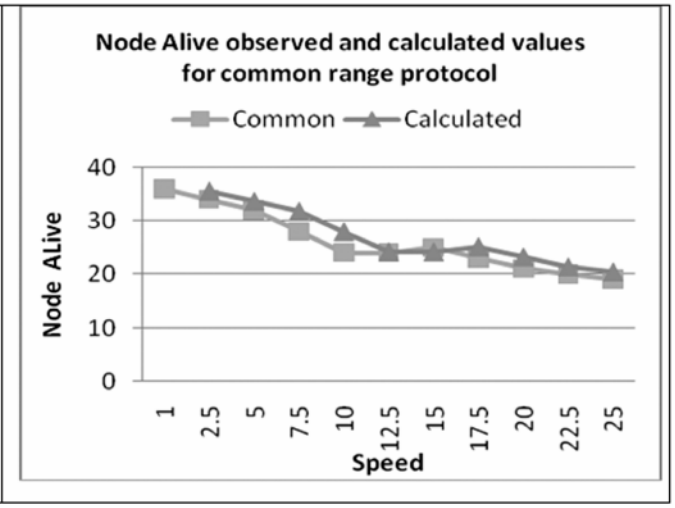

Figure 12: Observed, Calculated NA

6.3.3 Effect of Pause Time Variation on Two Protocols Common Range DSR and VRDSR

i) Network life time (for 50 nodes and speed 20 m/s)

Variable:

$$NLT_{(pt)} = 60.766 + 0.6723*NLT_{(pt-1)} + W_{(pt)} + 1.0*W_{(pt-1)} \quad (18)$$

ARMA model is found to fit the variable range protocol, estimated value is 179.97 in place of 178 for pause time as 100 s, 50 nodes and at speed of 20 m/s.

Common:

$$NLT_{(pt)} = 14.847 + 1.7347*\mathrm{NLT}_{(pt-1)} - 0.8167*NLT_{(pt-2)} \quad (19)$$

AR model is found to fit the common range protocol. The close match between observed and estimated values is seen in Fig. 13.

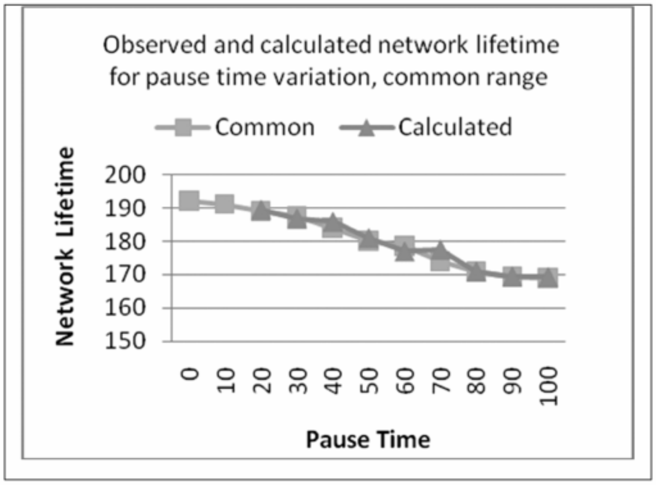

Figure 13: Observed, Calculated NLT, Pause Time Variation

7. CONCLUSION

The use of Variable range transmission overcomes the drawback of common range transmission in terms of energy consumption and improves network lifetime. The network parameters show improvement for node, speed and pause time variations for variable transmission range protocol.

The impact of three input parameter variation for variable range *DSR* can be summarized as:

i) *ARE* is reduced to greater extent in variable range transmission. Control overheads *NRL* and *NML* are less as compared to common range. *NA* and *NLT* are better.

ii) We can achieve better energy conservation and network lifetime even at higher mobility.

iii) For pause time variation, increase in Network lifetime is significant as the ability of node to forward the packet increases. This also ensures connectivity between the different nodes for a longer period.

For modified VRDSR protocol, the improvement in Number of alive nodes, network lifetime is due to transmitter power adjustment done at each node before transferring the data. This makes effective utilization of different nodes in the network possible.

Modeling helps in understanding the network better. We have confirmed the close match between simulation results and calculated values using our models for both the protocols. The model is valid as it gives results fitting empirical observations. This technique provides insight beyond what is already known from direct investigation of the phenomenon being studied. We can estimate new values using the models developed with the help of past inputs.

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